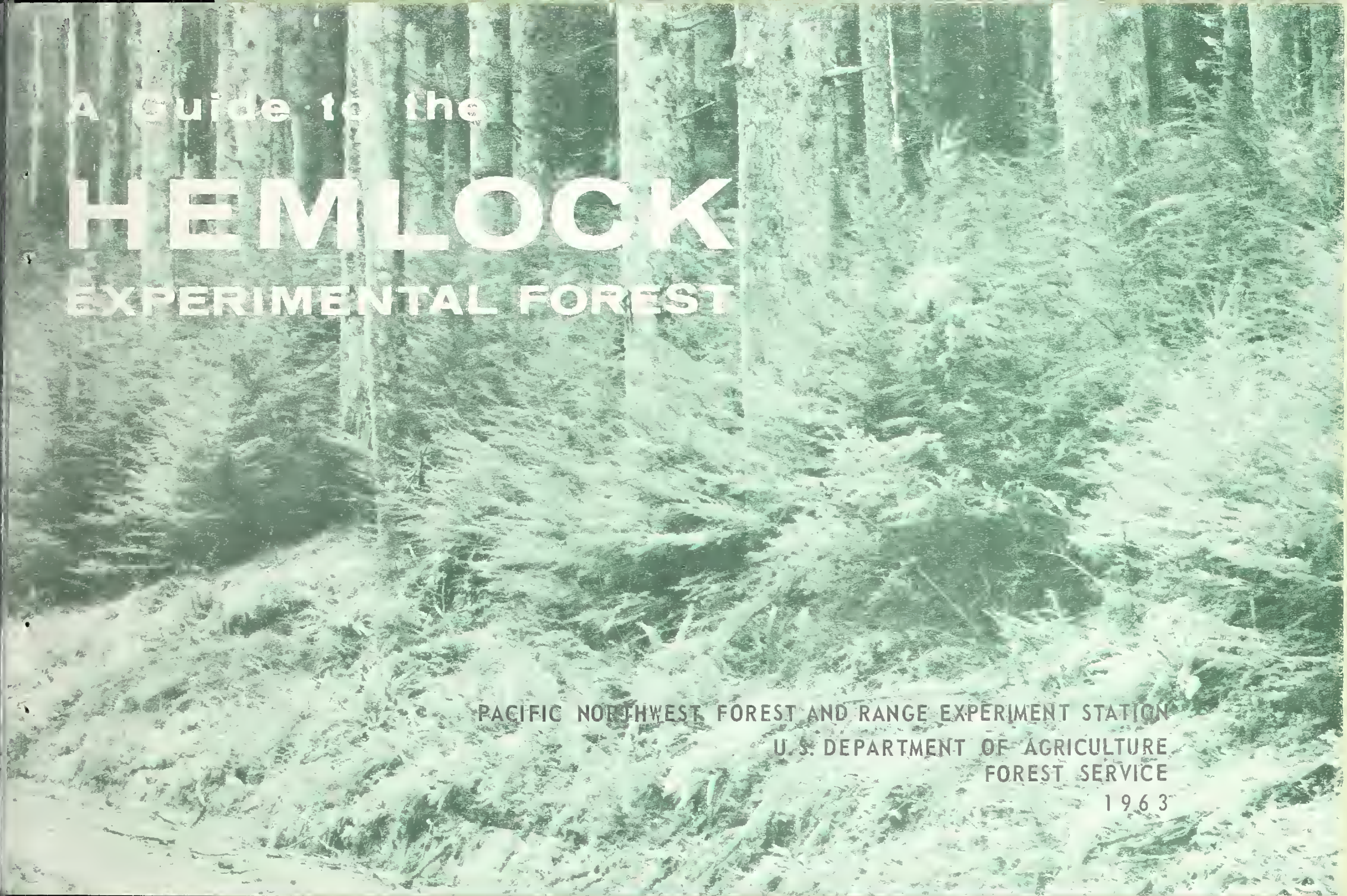


A Guide to the HEMLOCK EXPERIMENTAL FOREST

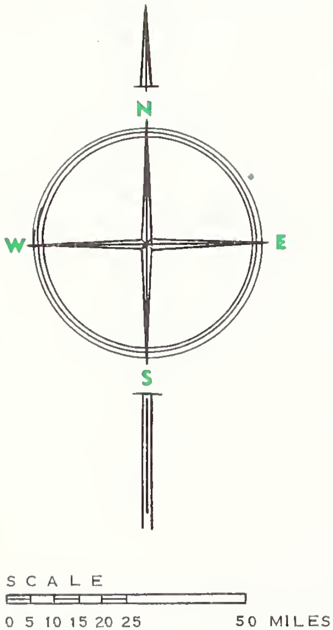
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
1963

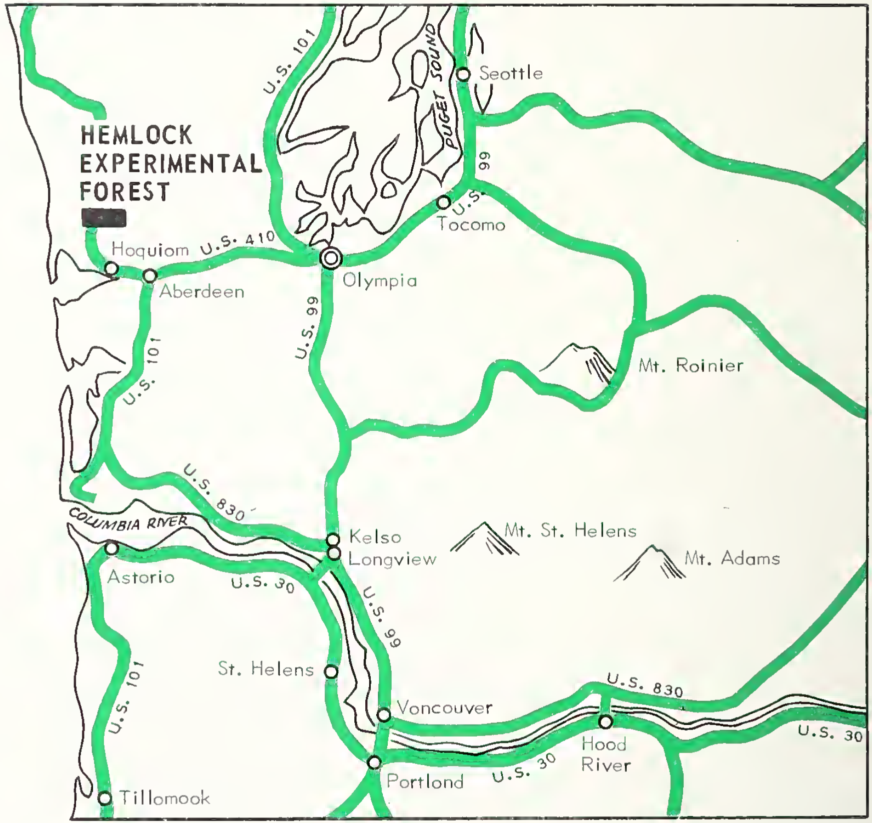
LOCATION MAP

OF THE

HEMLOCK

EXPERIMENTAL FOREST





MAY 1963

A GUIDE TO THE HEMLOCK EXPERIMENTAL FOREST

by EDWARD J. DIMOCK II

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PACIFIC NORTHWEST

FOREST AND RANGE EXPERIMENT STATION

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Portland, Oregon

INTRODUCTION

The Hemlock Experimental Forest in Grays Harbor County, Wash., is dedicated to silvicultural research and demonstration in nearly pure, young-growth western hemlock. Owned by the St. Regis Paper Co. and leased to the Forest Service under cooperative agreement, the Forest is administered by the Olympia Unit of the Pacific Northwest Forest and Range Experiment Station. The Olympia Unit conducts studies in young-growth management on three privately owned experimental forests in western Washington (see back cover).

A cooperative lease agreement officially created the Hemlock Experimental Forest in February 1949. At that time a nearly pure stand of 45-year-old western hemlock covered more than half of the 476-acre Forest. Open and mixed types containing Douglas-fir, western redcedar, and Sitka spruce, as well as western hemlock, prevailed over the balance.

The Forest is typical of large acreages of coastal western hemlock where stands have reached or are approaching merchantable size and age. The area is well suited to studies of thinning, harvest cutting, and the rehabilitation of poorly stocked areas.

Bisected by the "Olympic" highway (U.S. 101), the Experimental Forest lies about 10 miles south of Humptulips and 13 miles north of Hoquiam. The Forest is a 65-mile drive from the headquarters at Olympia.

PURPOSE

Research at Hemlock aims to develop and demonstrate silvicultural and management practices to increase productivity of young western hemlock forests of the coastal zone, more specifically to:

1. Develop procedures for reestablishing forest cover on nonstocked or poorly stocked bracken fern areas;
2. Determine desirable commercial thinning methods that will reflect consideration of cutting frequency and severity, tree selection, harvesting methods and equipment, and economic feasibility;
3. Investigate growth and yields in both thinned and unthinned stands; and
4. Devise methods for final harvest cuts in mature young stands that will provide adequate regeneration promptly and minimize loss in production during the regeneration period.

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TOPOGRAPHY

Situated on a divide between two major water courses, the Forest is drained on the west by the West Fork of the Hoquiam River and on the east by a branch of Big Creek. Big Creek, which flows north out of the Forest, eventually turns west before emptying into the Humptulips River. Both drainages terminate in Grays Harbor.

Highest (410 feet) and lowest (225 feet) elevations on the Forest are found on its western sector, which is typically dissected by low ridges and shallow swales. That part of the Forest lying east of U. S. Highway 101 is generally less precipitous with extensive areas of nearly flat land.

CLIMATE

The marine climate, typical of the Pacific Northwest coast, is unusually favorable for tree growth. Rainfall is abundant – approximating 100 inches annually – with 20 to 25 inches falling during the growing season. Only a small proportion of the total precipitation occurs as snow. Long-term average annual temperature is 50° F.; temperatures during the growing season average about 6° warmer. Freezing temperatures are limited to a few days during winter. Storm winds generally blow from the southwest.

SOIL

Clays, clay-bearing shales, conglomerates, and gravels typify soils of the Experimental Forest and surrounding land. The finer textured materials were deposited as marine sediments laid down and elevated during the Pleistocene period. Surface soils overlie massive sandstone and shale deposits of Tertiary origin.

With the exception of small areas of undifferentiated alluvium, one soil type, Hoquiam clay loam, covers the entire Forest. The soil is acid - varying from a pH of 4.6 to 4.8 in the surface layer to a pH of 5.0 to 5.2 at deeper levels. Both shallow and deep phases of this soil occur, the former being closely associated with steeper slopes.

Hoquiam clay loam is a moderately deep, well-drained forest soil. It is fairly stable, though it can be highly erosive on steep slopes following excessive removal of vegetative cover.

FOREST TYPES AND TIMBER VOLUMES

Stand history before establishment of the Hemlock Experimental Forest is somewhat obscure. The entire area was apparently logged shortly before 1900. A 1950 inventory showed that 65 percent of the area was occupied by pure stands of western hemlock, 8 percent by other conifer types, 24 percent by brush, principally bracken, and the remaining 3 percent by swamp or cleared land. Lists of vegetation types and plant species, plus a table of timber volumes, are given in the appendix.

A "large" western hemlock type, which covers over half of the Forest, became established about 1903. A "small" western hemlock type, which covers about 9 percent of the Forest, is 10 to 20 years younger and is generally less well stocked. Almost pure stands of western hemlock, such as these, typically originate after logging or extensive windthrow within the Washington coastal zone. Portions of the area now in pure western hemlock presumably were not burned after the original logging since residual old-growth western hemlock trees are scattered throughout.

The "other conifer" types, which contain western hemlock in mixture with Douglas-fir or western redcedar, are younger than the pure hemlock stands and have resulted from differing fire histories.

The open brush type is characteristic of stands subjected to repeated postlogging fires that prevent tree regeneration and favor brush encroachment. Of the scattered trees in the brush type few are older than 30 years and the majority are Douglas-fir. Failure of these open areas to restock satisfactorily during recent decades when no fires have occurred is attributed to a lack of well-distributed seed trees and the competition of aggressive brush.

Timber volume on the forested types of the Experimental Forest was estimated in 1960 at 2.7 million cubic feet, or 14 million board feet (International 1/4-inch rule). Western hemlock comprises about 85 percent of the cubic volume. Douglas-fir, western redcedar, and Sitka spruce make up most of the balance. Except in the open type, where volume is negligible and hence not recorded, hardwoods are conspicuous by their almost complete absence.

Forest Types

	Area (Acres)
Western hemlock ("large")	268.2
Western hemlock ("small")	42.5
Douglas-fir—western hemlock	14.1
Mixed conifers	12.8
Western hemlock—western redcedar	5.6
Western redcedar	3.3
Nonforest:	
Open brushland	114.2
Cleared land	9.6
Swampland	5.2
Total	475.5

Table 1. — Estimated timber volume of the Hemlock Experimental Forest [1]

Type and area	Species	Volume in -- Cubic feet [2] Total	Cubic feet [2] Per acre	Board feet,[3] International ¼-inch rule Total	Board feet,[3] International ¼-inch rule Per acre	Board feet,[4] Scribner rule Total	Board feet,[4] Scribner rule Per acre
Hemlock ("large") (268.2 acres)	Hemlock	2,218	8.3	11,807	44.0	10,664	39.8
	Other conifers	196	.7	854	3.2	704	2.6
	All conifers	2,414	9.0	12,661	47.2	11,368	42.4
Miscellaneous (83.5 acres)	Hemlock	198	2.4	838	10.0	730	8.8
	Other conifers	123	1.4	482	5.8	386	4.6
	All conifers	321	3.8	1,320	15.8	1,116	13.4
Combined (351.7 acres)	Hemlock	2,416	6.9	12,645	35.9	11,394	32.4
	Other conifers	319	.9	1,336	3.8	1,090	3.1
	All conifers	2,735	7.8	13,981	39.7	12,484	35.5

[1] Open types, totaling 123.8 acres, excluded. Volumes projected from 1949 inventory to reflect volume changes due to growth and timber removal through 1960.

[2] Trees 6 inches d.b.h. and larger to a 4-inch top.

[3] Trees 8 inches d.b.h. and larger to a 6-inch top.

[4] Trees 10 inches d.b.h. and larger to an 8-inch top.

GROWTH

Within the "large" hemlock type, net mean annual increment to 1960 was 158 cubic feet or 828 board feet (International 1/4-inch rule) per acre. The stand is now undergoing a period of rapid growth, and that portion in the major thinning experiment shows a net periodic annual increment of 179 cubic feet or 1,490 board feet per acre.

Because of their relatively small area, periodic growth within the "other conifer" forest types has not been analyzed. However, stands in this group are probably growing more slowly in volume but faster in growth percent than hemlock types since they are generally more poorly stocked.

ADMINISTRATION AND PROTECTION

Responsibility for forest protection, road development, and marketing of forest products rests with the St. Regis Paper Co. The Olympia Unit prepares the overall management plan, carries out all formal studies, conducts demonstration tours, and provides on-the-ground supervision of all thinning and harvesting.

Fire is the most serious protection problem on the Forest, particularly in the open, bracken-dominated northern sector. During early spring and fall, matted dead bracken fronds are highly inflammable. The Forest's well-timbered areas, in contrast, present a comparatively low fire risk.

Fire detection and suppression are provided by the State's Department of Natural Resources through its Montesano protection district. During the summer months a temporary guard station at Humptulips is manned by the State for the primary purpose of fire protection.

Damage from insects, disease, and wind has been light and of incidental occurrence. Although the current light timber cutting may increase decay (due to logging injury) and windthrow (due to increased exposure of tree crowns), these effects so far have proven negligible.

The poorly stocked open type provides excellent habitat for forest mammals — both large and small. Rabbits and mountain beaver, by clipping the foliage of coniferous seedlings and small saplings, impede the progress of timber restocking. Elk and deer compound the damage, mostly to sapling-sized conifers, through early-season browsing of new growth.

The most spectacular damage from wildlife is the girdling or scarring of young trees by black bears when feeding on tree sap (fig. 1). Although Douglas-fir is highly preferred, other tree species are not immune to bear attack. Damage may occur either at the tree base or high up in the crown and tends to be more prevalent on larger dominant trees. Even when not killed outright, such trees are often seriously deformed. Bear damage to Douglas-fir at Hemlock is most widespread in those stands with poorest stocking.

To alleviate rabbit damage to planted trees, personnel of the U. S. Fish and Wildlife Service have treated young trees in plantations with rabbit repellants. Some bear trapping by State hunters has also been carried on near the Forest for several years.

ROAD DEVELOPMENT

A primary access system for sustained operation of the Forest was virtually complete in 1962 and included recent construction or improvement of 3 miles of graveled, single-lane road. In addition, reconstruction of about a half mile of old woods road will give accessibility to the Forest's northwestern sector. Under the completed system each mile of road will service approximately 135 acres.

Investment in road development through 1961 totaled $21,026. Receipts from experimental timber harvests have returned $16,494 of this amount, leaving an unamortized road cost of $4,532.

Figure 1.—Douglas-firs severely scarred by black bears are particularly common on poorly stocked portions of the Experimental Forest.

RESEARCH PROGRAM

Planting studies were begun in 1950 and a major commercial thinning experiment in 1952. A study of regeneration cuttings by the shelterwood method was started in 1960.

Species Adaptability in Bracken

On the 124 acres of the Experimental Forest that are nonstocked or poorly stocked, the cover of western bracken inhibits natural seedling establishment and survival. To survive, a conifer seedling must successfully compete with bracken for light, nutrients, and moisture and also withstand the annual smothering effect of matted, dead fern fronds. These areas also provide highly favorable habitat for wildlife whose activities may further curtail growth or even cause seedling death.

Figure 2.---Plantation site in heavy ground cover of western bracken:
A, During the growing season much of the bracken cover is head high.

Over a 4-year period beginning in the spring of 1950, five native species — Douglas-fir, Sitka spruce, grand fir, western redcedar, and western hemlock — were planted in the bracken area along the Forest's north boundary. Each plantation covers about 6 acres (fig. 2).

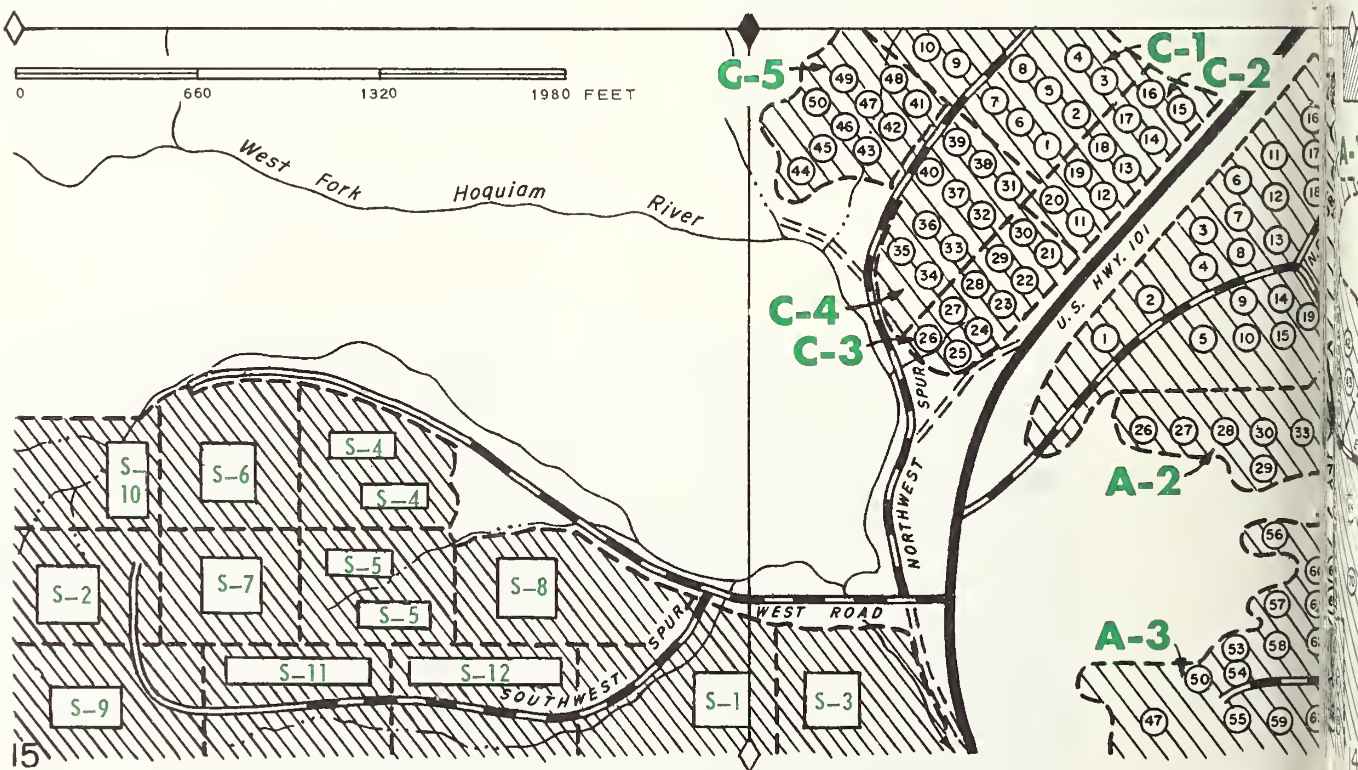
The Sitka spruce and grand fir plantings are clearly the least successful in terms of both survival and growth. Survival of western redcedar and western hemlock is considerably better, but height growth is unimpressive. In contrast, most of the surviving Douglas-fir seedlings now show promise of permanent establishment.

Methods of Planting in Bracken

Where western bracken grows densely enough to appreciably hinder planting success (fig. 3), special treatments will be needed to insure seedling growth and survival. Two possible approaches — arrestment of bracken development by mechanical means and

B, During the fall and winter, the bracken dies and forms a dense mat.

Location of Studies and Test Cuttings • N½sec. 14 a



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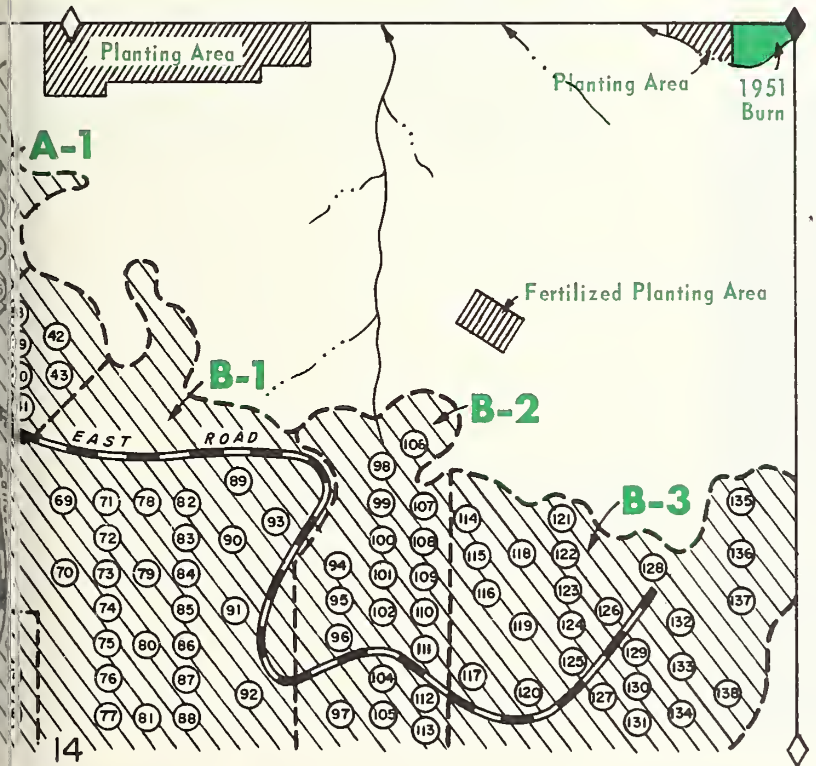

SHELTERWOOD TREES RESERVED IN FIRST CUT

	TREES PER ACRE	SPACING IN, FEET
Compartment S-1	200	14.8 x 14.8
Compartment S-2	162	16.4 x 16.4
Compartment S-3	132	18.2 x 18.2
Compartment S-4	107	20.2 x 20.2
Compartment S-5	87	22.4 x 22.4
Compartment S-6	71	24.8 x 24.8
Compartment S-7	58	27.4 x 27.4
Compartment S-8	47	30.4 x 30.4
Compartment S-9	38	33.9 x 33.9
Compartment S-10	31	37.5 x 37.5
Compartment S-11	25	41.7 x 41.7
Compartment S-12	20	46.7 x 46.7

THINNING

Compartment A-1	Low thinning, light frequent cuts
Compartment A-3	Low thinning, heavy infrequent cuts
Compartment B-1	High thinning, light frequent cuts
Compartment B-3	Low thinning, heavy infrequent cuts
Compartment A-2	Check area, no cutting
Compartment B-2	Check area, no cutting
Compartment C-5	Low thinning, light frequent cuts
Compartment C-3	Low thinning, heavy infrequent cuts
Compartment C-1	High thinning, light frequent cuts
Compartment C-4	High thinning, heavy infrequent cuts
Compartment C-2	Check area, no cutting

LEGEND

- S-1 Shelterwood treatment with sample plots
- 3 Thinning treatment with sample plots
- Compartment boundary and/or type line
- Intermittent stream
- Paved highway
- Unsurfaced road
- Gravel road
- Abandoned road

stimulation of seedling growth through fertilization — were combined in a study begun during the spring of 1957.

Briefly, the study includes a primary comparison of 2-0 Douglas-fir seedlings planted with and without nitrogen-phosphorus fertilizer and a secondary comparison of three mechanical treatments: (1) periodic cutting and removal of bracken fronds around planted seedlings, (2) installation of a paper overlay to impede bracken development around seedlings, and (3) an untreated control. The fertilizer used was a pelletized type designed to put in the planting hole with the seedling.

Figure 3.—Twelve years after planting, 2–0 Douglas-fir nursery stock has only partially succeeded in restocking this bracken-dominated site. Larger trees in background were established naturally.

After five growing seasons, the plantings failed to show any significant advantage for fertilizer treatment. Attempted modification of the bracken environment through frond cutting or use of paper overlays has likewise failed to improve seedling growth and survival (fig. 4). Survival has remained surprisingly high on all treatments, averaging 80 percent after 5 years. Height growth, on the other hand, has been low, with seedling height averaging less than 16 inches after 5 years.

Figure 4.—Although freed from aboveground competition by periodic cutting of adjacent bracken fronds, this Douglas-fir seedling shows little benefit five seasons after planting. Whitish compound on foliage is TMTD repellant to discourage rabbit depredations.

Silviculture of Commercial Thinning

The oldest major study, started in 1952, explores aspects of commercial thinning in the Forest's "large" hemlock type. This experiment involves a comparison of methods, intensities, and intervals of thinning with the primary object of measuring the effects of various treatments on stand growth and yield. Secondary objectives are: (1) to determine the nature and size of products that can be economically extracted, (2) to learn how thinning can be done at minimum cost and with minimum damage to the residual stand, and (3) to explore the financial implications of thinning. The areas thinned are sufficiently large to exemplify a commercial operation and provide demonstration as well as research values.

Five treatments, laid out in a randomized block pattern, are being studied:

1. Low thinning at 3-year intervals.
2. Low thinning at 6-year intervals,
3. Crown thinning at 3-year intervals,
4. Crown thinning at 6-year intervals, and
5. No thinning (check).

Generally, the volume removed in each thinning operation has closely approximated 85 percent of the gross cubic volume growth during the preceding 3- or 6-year period (fig. 5). In low thinnings, the goal is to cut trees averaging 3 inches *below* the mean stand d.b.h.; in crown thinnings, trees averaging 3 inches *above* the mean stand d.b.h.

During the first 6 years of the experiment, periodic annual net increment per acre has varied from 128 to 231 cubic feet:

Compartment	Thinning method and interval	Gross periodic annual increment (Cu. ft.)	Net periodic annual increment (Cu. ft.)
A-1	Low, 3 years	217	172
A-2	Unthinned	258	206
A-3	Low, 6 years	241	191
B-1	Crown, 3 years	261	231
B-2	Unthinned	159	128
B-3	Crown, 6 years	204	162

Figure 5.—Periodic stand growth within the thinning trials is determined by means of permanent sample plots remeasured just prior to each scheduled cutting.

These initial differences in growth are believed to be related more to variations in site and original stand density than to thinning treatment.

So far, the thinned and unthinned stands have shown little difference in mortality rates, ranging from 30 to 52 cubic feet per acre annually. However, about three-fourths of this loss is salvaged in thinning and represents realized increment that is otherwise lost in the unthinned stands.

Logging Methods in Commercial Thinning

Both tractor and horse logging have been employed in the thinning trials at Hemlock. Although the use of tractors was found to be more efficient for skidding the largest trees (old-growth residuals) and on a few long skidtrails with adverse gradients, horses have generally proved most successful. To date, horse logging has not only reduced total logging cost but has also lessened stand damage. All thinnings on the Experimental Forest have been contract operations.

Financial Aspects of Commercial Thinning

Detailed cost records have been kept on all thinnings since the start of the experiment. Earlier operations were essentially marginal, paying the operator a union-scale wage after allowance for all normal operating expenses but leaving little or nothing for stumpage. This failure to provide a stumpage return resulted from a combination of operator inexperience and poor market conditions. More recent operations, however, have not only permitted a modest stumpage charge but also allowed the operator a fair net profit in excess of wages (fig. 6). Production rates have

Figure 6.—This contractor improved efficiency in loading out 8-foot pulpwood by using a forklift loading device mounted on a farm tractor.

varied from a low of 1.08 cords per man-day in 1952 to a high of 2.68 cords per man-day in 1959, and over an 8-year period have averaged slightly better than 2 cords per man-day.

Decay from Logging Injury

Since western hemlock is a species that regenerates well on down logs (fig. 7), stumps, and heavy raw humus, trees in young-growth stands typically show pronounced root buttressing. Also, the species is relatively thin barked. Hence, even when logged with utmost care, western hemlock stands are subject to considerable damage during thinning operations (fig. 8).

A study conducted during the summer of 1958 showed that 33 percent of the stems in a stand thinned 6 years previously had been injured during thinning, and that 61 percent of the wounded trees had identifiable decay within the resultant scars. A strong relationship was found between decay incidence and

Figure 7.—Western hemlock typically regenerates on decaying down logs. This row of 28 hemlocks, all originating on the same fallen tree, was cut in right-of-way construction.

scar size. Scars with decay averaged about 1 square foot in original surface area, whereas scars without decay were only one-fifth this size. Moreover, about three-fourths of the scars in contact with the ground (root or basal scars) had decay; scars higher up were infected less frequently.

From 50 scars containing decay, six fungi were identified. *Fomes annosus* accounted for by far the greatest amount of decay (79 percent) in the scars sampled.

These results suggest that decay entering through logging scars resulting from thinning may seriously influence the volume and quality of final yields.

Final Harvest by Shelterwood Method

Because clear cutting has become a rather standard and accepted method of harvest cutting throughout western Oregon and Washington, the stimulus to explore other harvest systems is not overly great. Moreover, partial-cutting methods proved to be poorly adapted for use in old-growth timber. Shelterwood cutting, however, shows considerable promise for final harvests in young-growth western hemlock. A study of this method was established in 1960-61 on a 65-acre area of the "large" hemlock type on the west side of the Experimental Forest. Twelve cutting intensities are being compared with initial residual stands varying from 20 to 200 trees per acre. Second and third (final) cuttings will be made on all compartments at intervals of 5 years.

Final results will be measured in terms of number, distribution, initial growth, and thrift of hemlock seedlings. Other factors such as competition from other plant species, light intensity, aspect, slope, seedbed conditions, and seed fall will also be evaluated.

Figure 8.—Flaring root collars on most dominant western hemlocks appear particularly susceptible to skidding injury. Note the partially healed scars above the fresh wounds near ground level.

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Worthington, Norman P.
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APPENDIX

Plant Species

Common and scientific names of plants present on the Experimental Forest follow. Those included in "Check List of Native and Naturalized Trees of the United States (including Alaska)" (U.S. Dept. Agr. Handb. 41, 1953) are named accordingly. Others are named according to "Standardized Plant Names" (Kelsey and Dayton, Ed. 2, 1942).

Tree species indigenous to the Forest are:

Western hemlock . . . . *Tsuga heterophylla*
Douglas-fir . . . *Pseudotsuga menziesii* var. *menziesii*
Western redcedar . . . . *Thuja plicata*
Sitka spruce . . . . *Picea sitchensis*
Red alder . . . . *Alnus rubra*
Pacific willow . . . . *Salix lasiandra*
Western white pine . . . . *Pinus monticola*
Cascara buckthorn . . . . *Rhamnus purshiana*
Vine maple . . . . *Acer circinatum*

Lesser vegetation includes a fairly wide variety of shrubs, ferns, and herbaceous plants — the most conspicuous of which are:

Shrubs

American devilsclub . . . . *Oplopanax horridus*
Cascades mahonia . . . . *Mahonia nervosa*
Ovalleaf whortleberry . . . . . . *Vaccinium ovalifolium*
Pacific red elder . . . . *Sambucus callicarpa*
Red whortleberry . . . . *Vaccinium parvifolium*
Rusty menziesia . . . . *Menziesia ferruginea*
Salal . . . . *Gaultheria shallon*
Salmonberry . . . . *Rubus spectabilis*
Western thimbleberry . . . . *Rubus parviflorus*
Trailing blackberry . . . . *Rubus macropetalus*

Ferns

Deerfern . . . . *Blechnum spicant*
Ladyfern . . . . *Athyrium filixfemina*
Western bracken . . . . *Pteridium aquilinum pubescens*
Western swordfern . . . . *Polystichum munitum*

Herbaceous Plants

Characteristically open grown:

Common coltsfoot . . . . *Tussilago farfara*
Common foxglove (introduced) . . . . *Digitalis purpurea*
Common pearleverlasting . . . *Anaphalis margaritacea*
Fireweed . . . . *Epilobium angustifolium*
Vetch . . . . *Vicia* sp.

Characteristically under dense forest canopy:

Beadruby . . . . *Maianthemum dilatatum*
Bedstraw . . . . *Galium* sp.
Minerslettuce . . . . *Claytonia perfoliata*
Oregon oxalis . . . . *Oxalis oregana*
Pacific trillium . . . . *Trillium ovatum*
Skunkcabbage . . . . *Symplocarpus foetidus*
Trefoil foamflower . . . . *Tiarella trifoliata*
Twinflower . . . . *Linnaea borealis*
Western starflower . . . . *Trientalis latifolia*

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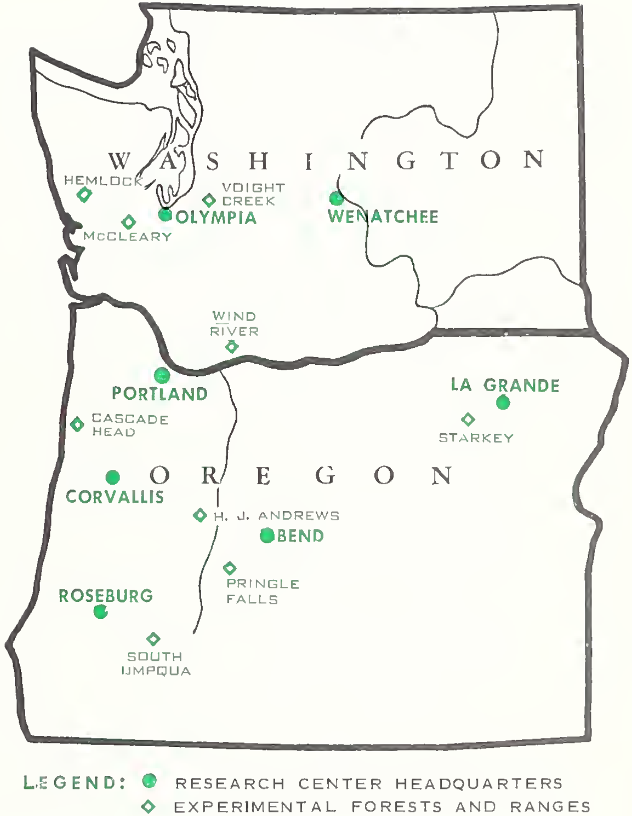

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NATIONAL FORESTS
Lands of many uses